

REMARKS

The applicants have carefully considered the Office action dated August 6, 2004 and the references it cites. By way of this Response, claims 1, 4, and 6-8 have been amended, and claims 2, 3, and 10-12 have been cancelled without prejudice to their further prosecution. In view of the following, it is respectfully submitted that all pending claims are in condition for allowance and favorable reconsideration is respectfully requested.

As an initial matter, the applicants note that they have corrected several minor typographical and grammatical errors in the specification. No new matter has been added. The amendment to paragraph [0019] merits discussion. The range in paragraph [0019] has been amended for consistency with original filed claim 12. Because the correct range for the nitride barrier layer 33 was recited in claim 12 of the application as originally filed, this amendment to the specification does not add new matter to the application.

Turning to the art rejections, the Office action rejected claims 1-12 as being unpatentable over one or more of Noguchi, U.S. Patent Application Publication, 2003/0114000 A1 and Agnello et al., U.S. Patent 6,255,217. The applicants respectfully traverse these rejections.

Independent claim 1 is allowable. Claim 1 recites, among other things, removing a copper oxide layer parasitically formed on the copper layer by performing a plasma process using nitrogen gas; forming a copper nitride layer having a thickness of about 50 to 200 Å on the exposed surface of the copper layer; and depositing a copper barrier layer on the insulating layer and the copper nitride layer, wherein the copper barrier layer is a nitride layer

having a thickness of about 50 to 200 Å. Neither Noguchi, nor Agnello, whether taken alone or in combination, teach or suggest such a method.

For example, while Noguichi does indicate that an “ammonia plasma treatment may be conducted as reducing treatment,” (Noguichi, paragraph [0235]), and that “hydrogen plasma and ammonia plasma may be used in combination,” (Noguichi, paragraph [0233]), it nowhere teaches performing a plasma process using nitrogen gas. Given Noguichi’s heavy emphasis on using ammonia and hydrogen plasma treatments, (see Noguichi, paragraph [0233] stating, “By carrying out hydrogen plasma treatment and ammonia plasma treatment in this order, it is possible to reduce the surface of the inlaid second-level interconnect L2”), Noguichi also cannot fairly be said to suggest performing a plasma process using nitrogen gas to remove a copper oxide layer from the copper layer.

Further, while Noguichi does mention that a copper nitride layer is formed on the upper surface of the lower interconnect L2, it does not teach or suggest that the presence of a copper nitride layer having a thickness of about 50 to 200 Å can be used with a copper barrier layer of nitride having a thickness of about 50 to 200 Å. Indeed, the copper nitride layer of Noguichi is apparently removed when forming the upper interconnect L3, or else is of insignificant thickness, since no copper nitride layer is illustrated between the lower interconnect L2 and the upper interconnect L3 in FIG. 17 of Noguichi.

This difference is significant. Employing a copper nitride layer with a thickness of about 50 to 200 Å and a copper barrier layer having a thickness of about 50 to 200 Å as recited in claim 1 functions to reduce the permittivity

of the insulating layer of the semiconductor device manufactured by the claimed method. No such structure or advantage is taught or suggested by Noguichi.

Agnello does not overcome the deficiencies of Noguichi. Agnello nowhere teaches or suggests the formation of a copper nitride layer between the upper and lower interconnects 20. Indeed, the upper and lower interconnects in Agnello are illustrated as being in direct engagement. Consequently, irrespective of how one combines Noguichi and Agnello, one does not arrive at the combination recited in claim 1. Accordingly, claim 1 and all claims depending therefrom must be allowed.

If the Examiner is of the opinion that a telephone conference would expedite the prosecution of this case, the Examiner is invited to contact the undersigned at the number identified below.

Respectfully submitted,

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